Medical Isotopes and Uses

Est. Length: up to 6 hours
Objective Review

- EO 1 – State why radiation is used to sterilize medical equipment.
- EO 2 – Describe how medical equipment is sterilized.
- EO 3 – Explain how radioactivity is used in new drug research.
- EO 4 – State why new drugs are tested with radioisotopes.
- EO 5 – Describe how imaging improves medical treatment.
- EO 6 – Explain how an X-ray image is produced.
Objective Review

- EO 7 – Describe how a computerized tomography (CT) scan is produced.
- EO 8 – State how magnetic resonance imaging differs from X-ray imaging.
- EO 9 – Describe positive emission tomography (PET) scanning.
- EO 10 – State common uses for the various medical imaging technologies
- EO 11 – Discuss internal and external radiation therapy.
- EO 12 – Explain the purpose of the most common radioisotopes.
Objective Review

EO 13 – Discuss the use of Tc-99m as a medical isotope.

EO 14 – State why Tc-99m is the most common radioisotope.

EO 15 – Describe how Mo-99 is created.

EO 16 – Describe the process for obtaining Tc-99m.

EO 17 – Describe how Co-60 is used in medical treatment.

EO 18 – Explain how I-131 and Ir-192 are used as radioisotopes in medical treatments.

EO 19 – Discuss the regulations regarding shipping medical isotopes.

EO 20 – Describe the role of a source custodian.
Medical Isotopes

- Increasingly popular with millions of procedures every year
  - Sterilization
  - New Drug Testing
  - Imaging for Diagnostics
  - Internal and External Therapy
Sterilization by Radiation

- Radiation disrupts the DNA
- Cells die
- Item is cleaned and bagged prior to sterilization
Tagging New Drugs

- Used during research and development
- Where does the drug go?
- Non-target area affects
Imaging

- Non-evasive, rapid assessments
- Includes:
  - X-ray
  - CT
  - MRI
  - PET
  - SPECT
X-ray

- Produced by electricity
- Bones and air spaces show best
- Insufficient details for organs
CT Scan

- Similar to X-ray
- Multiple images from different angles
- 3-D
CT Images

Gall stones

Figure 1

Figure 2

Normal kidneys

Diseased kidneys
MRI

- Non-ionizing radiation
- Far greater detail than X-rays
- Magnetic field “lines up” magnetic particles in body
MRI Images

Normal Knee

- Normal joint space.
- No osteophytes.
- No subchondral sclerosis.

Arthritic Knee

- Joint space reduced.
- Osteophytes.
- Subchondral sclerosis.
3D MRI Image
PET and SPECT

- Machine is similar to MRI or CT scanner
- Detects radiation from tracer
- Can be over-layered with CT scan for detailed views
PET Basics

How does a PET scan work?
PET Brain Scans

- Normal
- Mild cognitive impairment
- Alzheimer's disease
Mets or metastases are secondary cancer growths away from the primary cancer
SPECT Scan

- Blood flow and organ activity
- When combined with MRI, very detailed
Radiation Therapy

- Used for treatment instead of diagnosis

- External Therapy
  - High doses with pinpoint accuracy

- Internal Therapy
  - Targets a specific organ or area
External Radiation

- Beam is directed at a target
- Kills cells
- Beam is focused and penetrated at different angles to minimize dose to good cells.
Internal Therapy

- Meant to treat a specific organ or area
- Injected or deposited
List of Common Radioisotopes

- Dozens exist, but the most common are:
  - Tc99m
  - Co-60
  - I-131
  - Ir-192
Tc-99m

- Most common radioisotope
- “m” is for metastable
- Used for scans of:
  - Bones
  - Kidneys
  - Heart
  - Lungs
Advantages of Tc-99m

- Short half-life
- Gamma rays
- Sufficient energy
- Versatile chemistry
Tc-99m SPECT/CT
Mo-99 Production

- Only 5 reactors in the world produce Mo-99 from highly enriched U-235.
- Loss of any one severely impacts industry
- Only one in North America
  - Operating since 1957
U-235 Target

- U-235 target with aluminum cladding (peeled away)
- Fission of U-235 yields about 6% Mo-99
- Placed in reactor for 5-7 days
Mo-99 Separation

- Mo-99 must be separated from other fission products
- Work done in hotcells
- Purified solution is made and shipped
Tc-99m Generator Production
Tc-99m Generator

- Used by hospital personnel to extract the Tc99m for injection
- Received and used in short time period
- Because of shielding, can weigh as much as 400 lbs when shipped
Tc-99m Generator Chemistry

- A sterile saline solution is introduced
- Tc-99m is "milked" from the column
- Sterile solution is injected into the patient

![Diagram of Tc-99m Generator](image)

Basic principles of a $^{99}$Mo-$^{99}$Tc$^m$ generator.
### Decay of Mo-99, Tc-99m

#### Mo-99 in Generator

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#### Tc-99m in patient

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Gamma Knife Therapy

- Extremely accurate
- Used for tumors
- 200 or more beams focused on a small spot
Brachytherapy

- Internal therapy
- I-131 (thyroid)
- Ir-192 (breast/prostate)
- Seed is planted at diseased area
Brachytherapy
Shipping regulations set by:
- NRC
- DOT
- USPS
- DOE

NRC and DOT are primary
Training

The DOT requires haz-mat training for involved individuals that includes:

- General Awareness
- Safety
- Security
- Function Specific
Laboratory Handling
Source Custodian

- Source Custodian responsible for:
  - Receipt
  - Labeling and Storage
  - Inventory
  - Disposal

- Lost source must be reported
Questions??
Radioisotopes are part of the medical arsenal used all over the world. Their use is increasing every day and trained persons in the field are becoming needed more and more.

We will review the learning objectives to ensure understanding.